CHICAGO REGIONAL HOUSEHOLD TRAVEL INVENTORY

GPS FINAL REPORT

PREPARED FOR

CHICAGO METROPOLITAN AGENCY FOR PLANNING

TRAVEL TRACKER SURVEY

Your Travel Counts!

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INTRODUCTION

The Chicago Regional Household Travel Inventory (CRHTI) is a comprehensive study of the demographic and travel behavior characteristics of residents in the greater Chicago area. Sponsored by the Chicago Metropolitan Agency for Planning (CMAP), the Illinois Department of Transportation (IDOT), the Northwestern Indiana Regional Planning Commission, and the Indiana Department of Transportation, the study universe is defined as households residing in the Illinois counties of Cook, DuPage, Grundy, Kane, Kendall, Lake, McHenry, and Will and in the Indiana counties of Lake, LaPorte, and Porter.

The primary objective of the study was to provide data for the continuing development and refinement of the Chicago regional travel demand forecast models. Data were obtained using standard travel survey methods through the Travel Tracker Survey. This survey entailed the collection of activity and travel information for all household members regardless of age during a randomly assigned 24-hour or 48-hour period. The survey relied on the willingness of regional households to (1) provide demographic information about the household, its members and its vehicles and (2) have all household members record all travel and activity for the travel period, including address information for all locations visited, trip purpose, mode, and travel times.

In addition to demographic and travel behavior characteristics identified through the Travel Tracker Survey, the CHRTI includes travel data captured through the use of Global Positioning System (GPS) technology. Over the past decade, transportation researchers have leveraged GPS technology to improve the accuracy and increase the depth of spatial and temporal details. These additional details gleaned through GPS provide insights into travel patterns and household interactions. As identified during the expert panel meetings held during the design phase of the project, interest in GPS was focused on high mileage households and those who travel by walk and/or bike. The purpose of this report is to provide details regarding the GPS component.

The GPS approach evolved through the life of the project. Stage 1 focused on in-vehicle deployments to households that traveled a lot (travel throughout the region as part of their job or who traveled into Chicago for personal or business reasons at least three times per week) for the same day that the household members recorded travel. Stage 2 loosened the eligibility requirements by seeking households with at least one member making 10+ trips per day by auto or who traveled more than 75 miles per day as part of their job. In Stage 3, the focus on heavy travelers continued but the deployment period for the in-vehicle component was extended from 1 to 7 days. In Stage 4, a second on-person component (also for 7 days) was added. Stage 1 was conducted from January through mid-March, 2007. Stage 2 was conducted from mid-March through May 2007. Stage 3 began in May 2007 and continued through October 2007. Stage 4 (wearables component) was conducted from September through December 2007.

The CRHTI was designed by a team of consultants, led by NuStats. NuStats led the survey design effort, managed data collection, processed and geocoded the data, provided quality control and assurance, summarized the survey data, and created the weighting and expansion. PTV DataSource conducted the telephone interviews and mailed the travel log packets. GeoStats fielded the GPS survey supplement and prompted-recall survey. PB Consult updated the inventory with modeling-enhanced data and conducted independent assessments of the data quality. In addition, the project team included independent consultants: Mark Bradley, Dr. Chandra Bhat, Mary Kay Christopher, and Keith Lawton; and input from an expert peer panel.

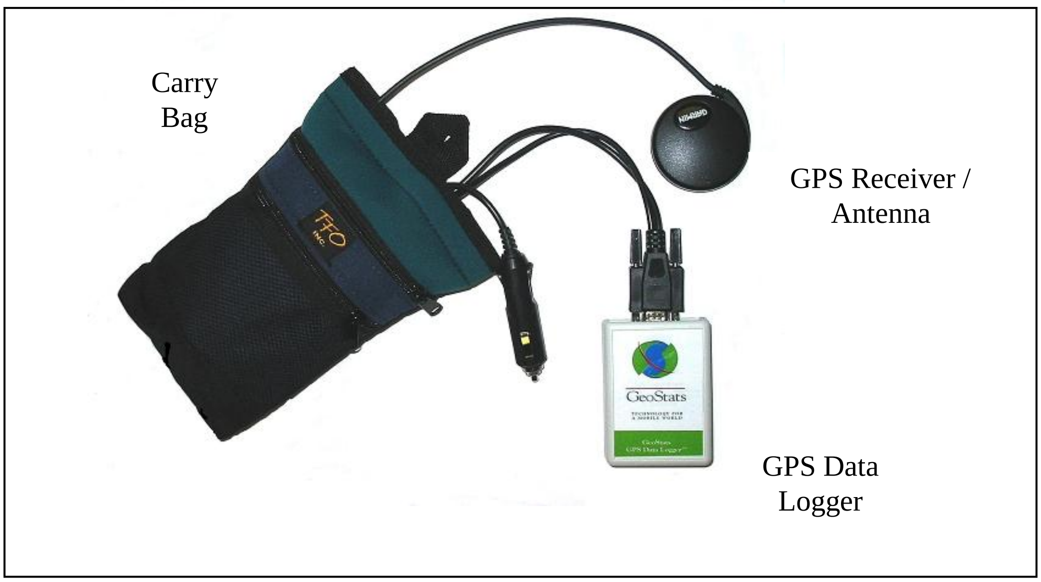
GPS EQUIPMENT

The CHRTI includes GPS-based travel details obtained through the use of two different types of GPS units: in-vehicle and wearable. The technical details regarding each unit type are discussed in this section.

IN-VEHICLE GEOLOGGER

The In-Vehicle GeoLogger is a rugged yet simple GPS data-logging device developed specifically for use in building travel inventories and conducting travel time studies. As shown in Figure 1, the GeoLogger consists of three components: the data collection device (the white box), a GPS receiver/antenna combination that is placed on the dashboard near the windshield, and the power cord, which plugs into the cigarette lighter or an auxiliary 12-volt power outlet in the vehicle. Installation of the GeoLogger required plugging the unit into the power source and placing the GPS receiver/antenna on the dashboard. This device is totally passive; once the unit is installed in a given vehicle, no further action (or interaction) with the unit is required. Given that many people use their vehicle's power outlets to power other devices, such as mobile phones, a power splitter was also provided to enable the participant to power both the GeoLogger and another device. In addition, a carry bag was provided for ease of deployment and retrieval of the equipment.

FIGURE 1: THE GEOSTATS IN-VEHICLE GEOLOGGER



Source: GeoStats

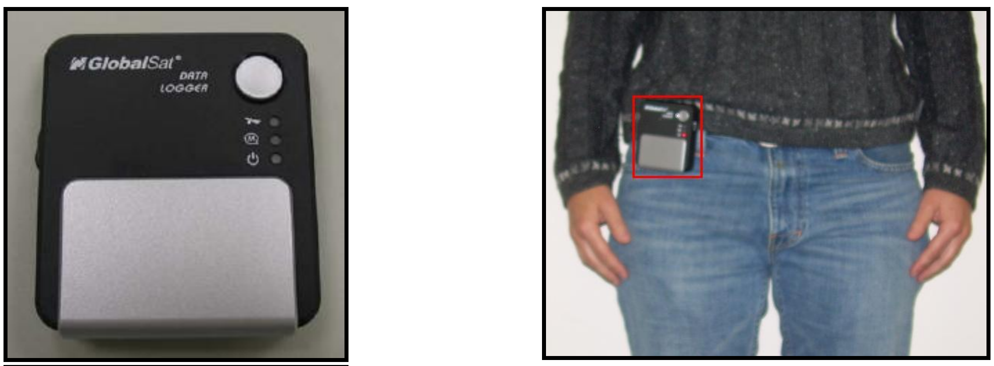
For this study, the GeoLogger was programmed to log the vehicle's position at one-second intervals and all valid GPS points for which the speed is greater than 1 MPH (to screen out non-movement events). It had 4 MB of data storage (good for 466,000 GPS points), which was more than sufficient for the needs of this project. The standard GPS data steam elements recorded by the GeoLogger included date, time, latitude, longitude, speed, heading, altitude, number of satellites, and horizontal dilution of precision (a measure of positional accuracy). These elements were stored in the logger in standard National Marine Electronics Association (NMEA) formats and converted to user-specified formats upon downloading.

WEARABLE GLOBALSAT GPS DATA LOGGER

The GlobalSat Data Logger (see Figure 2) is the device used for the wearables component of the study. It is lightweight (6 oz) and small (2.75”x3.15”x.7”) and, when fully charged, can collect data for 18-22 hours. It was designed to be worn on the waist, clipped to a purse or backpack, or dropped in a suit jacket pocket and is powered by two rechargeable AA batteries. Study participants were instructed to carry the GlobalSat with them anytime they went outdoors and to charge the device at the end of each day.

For this study, the device was programmed to log valid GPS positions for which the speed was greater than one MPH at five-second frequencies. It has a 60,000 GPS point storage capacity.

FIGURE 2: THE GLOBALSAT GPS DATALOGGER



Source: GeoStats

The standard GPS data stream elements recorded by the GlobalSat include date, time, latitude, longitude and speed. These elements are stored on the logger in standard NMEA units and were converted into user-specified units and formats upon download.

STUDY METHODS

The GPS component of the CHRTI relied on the willingness of a subsample of households to (1) agree to keep 24-hour travel logs for all household members, (2) accept equipment for up to 3 household vehicles or members, and (3) carry the equipment (in their vehicles or on-person) for the required period. Participating households completed all stages of the 24-hour Travel Tracker Survey (see Final Study Report for details). They also had additional contact with the GPS deployment team to accept and return their GPS units, and, if in the wearables component, were responsible for nightly recharging of the units. The purpose of this section is to review the methods associated with the GPS component.

The GPS study methods evolved through the life of the project.

- Stage 1 focused on in-vehicle deployments to households that traveled a lot (travel throughout the region as part of their job or who traveled into Chicago for personal or business reasons at least three times per week) for the same day that the household members recorded travel.
- Stage 2 loosened the eligibility requirements by seeking households with at least one member making 10+ trips per day by auto or who traveled more than 75 miles per day as part of their job.
- In Stage 3, the focus on heavy travelers continued but the deployment period for the in-vehicle component was extended from 1 to 7 days and general sample households (those not defined as heavy travelers but who still met the other requirements) were allowed into the effort (although the priority was still the heavy travelers).
- In Stage 4, a second on-person component (also for 7 days) was added.

Stage 1 was conducted from January through mid-March, 2007. Stage 2 was conducted from mid-March through May 2007. Stage 3 began in May 2007 and continued through October 2007. Stage 4 (wearables component) was conducted from September through December 2007.

Regardless of the stage or the focus of the GPS effort (in-vehicle or on-person), the GPS study centered about five main activities: (1) identification of interested households, (2) recruitment, (3) deployment of equipment, (4) retrieval of equipment, and (5) data processing. The final tasks included a comparison of CATI-reported vs. GPS-captured trips (with details on differences noted between the two data sources informed through a prompted recall survey) and the creation of the final data files. Throughout both efforts, participating households were expected to have all members of the household complete 24-hour travel logs in support of the main Travel Tracker Survey. This section of the report provides details about each of these stages for both the in-vehicle and on-person efforts.

IN-VEHICLE GPS EFFORT

Stages 1 through 3 of the GPS component focused on the deployment of in-vehicle GPS devices for up to three vehicles per household, with the main differences between the stages being the identification of eligible households and the deployment period, as discussed above. The details regarding this effort are included in this section.

Identification of Interested Households

As the households agreed to participate in the 24-hour component of the Travel Tracker Survey, the computer-aided telephone interviewing (CATI) program flagged households that met eligibility requirements for the GPS effort. Key criteria for inclusion in the in-vehicle GPS effort included:

1. Household reported owning at least one household vehicle.
2. Household reported that each vehicle owned (to the best of their knowledge) had a functioning cigarette lighter or 12-volt power adapter.
3. Household reported at least one household member who either was a heavy traveler (at least 75 miles on a typical weekday) OR who drove to downtown Chicago at least three times per week (later modified to making at least 10 trips per day).

As eligible households were identified, the CATI prompted the interviewers to identify interested households through the script shown in Figure 3. The same script was used for all three stages of the in-vehicle GPS effort, with the exception that in Stage 3, the extension of the deployment period from one day to seven days was reflected in a simple update to the text to indicate that the equipment would be installed for one week rather than one day.

FIGURE 3: INTEREST IN IN-VEHICLE GPS STUDY PARTICIPATION

In addition to asking everyone to record their travel information in the travel log, we're selecting a handful of households to help test the use of Global Positioning System, or GPS, technology, in conducting travel surveys. If selected, we would contact you and deliver GPS devices to you for each vehicle in your household. All you would need to do is plug the device into your car's cigarette lighter or power outlet. Once you plug it in, there's nothing else to do except to leave it there during your assigned travel day. The process is very simple and the results of this test can lead to improved travel studies in the future. If selected, will you help us with the test?

Of the 10,121 households recruited for the 24-hour portion of the Travel Tracker Survey, 6,520 (65%) met the eligibility requirements for inclusion in the in-vehicle GPS effort. Of the 6,520 households eligible for GPS, 2,992 (46%) were eligible under the heavy traveler criteria and 3,528 (54%) were eligible based on vehicle ownership and functioning outlets (the general population).

Of the 6,520 households eligible for inclusion in the GPS effort, 1,550 indicated they were interested in participating in the GPS effort. Table 2 shows the characteristics of the 1,550 interested households as compared to all households recruited into the 24-hour Travel Tracker Survey. As indicated therein, interested households were larger and, by definition, had more vehicles. They tended to report higher incomes and live in a single family dwelling. They were also less likely to be of minority descent.

TABLE 1: CHARACTERISTICS OF HOUSEHOLDS INTERESTED IN IN-VEHICLE GPS

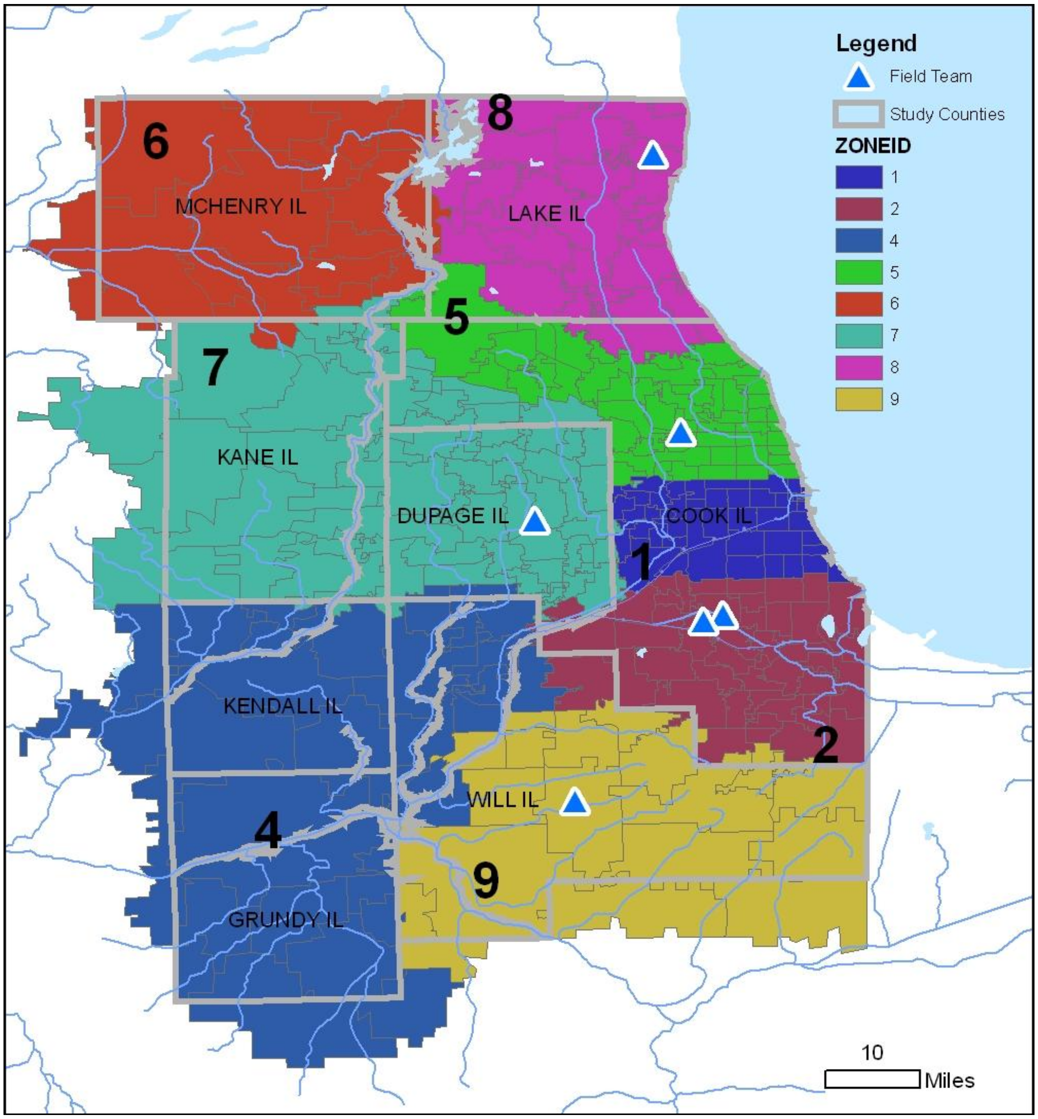
	All 24-hour Recruits	In-Vehicle GPS Interested Recruits	CMAP Region Census Data
Household Size			
1	28.2%	22.3%	26.4%
2	34.7%	37.0%	28.7%
3	14.9%	16.3%	16.2%
4+	22.2%	24.4%	28.9%
Household Vehicles			
0	11.1%	0.0%	14.3%
1	35.7%	35.4%	36.3%
2	37.7%	45.4%	36.1%
3+	15.5%	19.2%	13.3%
Household Income			
< $20k	13.0%	5.1%	16.9%
$20k - < $35k	11.6%	8.6%	15.7%
$35k- < $50k	14.2%	13.8%	15.3%
$50k - < $75k	19.0%	20.3%	20.9%
$75k - < $100K	16.0%	17.8%	12.9%
$100k +	26.2%	34.4%	18.3%
Income refusals	12.1%	6.5%	--
Residence Type			
Single family	60.3%	66.2%	55.6%
All other types	39.7%	33.8%	44.4%
Ethnicity			
White	75.0%	77.1%	65.5%
Black/African American	11.5%	10.0%	18.9%
Other	13.5%	12.9%	15.6%
Hispanic			
Yes	8.9%	8.8%	17.2%
No	91.1%	91.2%	82.8%
Respondent Age			
<20	24.1%	24.3%	29.5%
20 - 24	4.4%	5.0%	6.7%
25 - 54	40.2%	42.8%	45.1%
55 - 64	14.2%	14.5%	8.0%
65+	17.1%	13.4%	10.7%
Age refusals	2.9%	2.2%	--

Source: CHRTI 24-hour Recruitment Data, unweighted.

GPS Study Recruitment

To handle deployment of GPS equipment across the study area, GeoStats divided the region into deployment zones and contracted with retired police officers to handle the deployments within these zones. Figure 4 show the zones, with the triangles indicating the home locations of the deployment team.

FIGURE 4: IN-VEHICLE GPS DEPLOYMENT ZONES



As the daily processing of the recruitment data from the 24-hour Travel Tracker Survey took place, those households that indicated an interest in the GPS study were flagged and extracted into a separate GPS recruitment file. This file was transmitted to GeoStats three times a week, where the file was imported into their GPS household database and automatically assigned a deployment zone based on home location. The recruited households would then be displayed a secure website, where the deployment team members would log on and initiate the scheduling of deployments.

Equipment Deployment

The deployment team members signed onto the password-protected website on a daily basis to review the households that had indicated an interest in participating in the GPS study and attempt to deploy to the households within the days leading up to the assigned travel day. The lead time between the posting of recruited/GPS interested households to the website and the assigned travel date was at least seven days, allowing sufficient time to reach the households and to schedule GPS equipment delivery prior to the assigned travel date.

Each team worked to maximize the number of GPS deployments subject to a constraint of available equipment. Multiple attempts were made to reach each interested household, with call outcomes updated on the GPS project management website at GeoStats. As households were contacted, they were reminded of their earlier interest in participating in the study and the deployment team member attempted to schedule a delivery.

The deployment effort results are shown in Table 2, by geographic strata. Of the 1,550 interested households, deployment was attempted for 1,397, the remaining 153 households did not have a geocoded home address at the time of recruitment and thus were excluded from the GPS effort. Of the 1,397 interested households, 300 (22%) received GeoLoggers for up to three vehicles in their household. Efforts were made to deploy to an additional 26 households, but 11 of those households were not home at the appointed time and an additional 15 households refused the equipment when the deployment team arrived for installation.

TABLE 2: IN-VEHICLE GPS DEPLOYMENT OUTCOMES

Strata	Total Recruited	Deployed	Missed appointment	Refused on delivery	Refused when called	Could never reach	Not Attempted
1	345	80	3	5	45	49	163
2	411	97	2	4	50	71	187
3	416	82	3	5	45	87	192
4	158	26	2	1	12	47	69
5	67	15	1	0	7	19	25
TOTAL	1397	300	11	15	159	273	636
%	100%	21.5%	0.8%	1.1%	11.4%	19.6%	45.6%

Of those households not deployed to, 11% refused to participate when they were called to schedule a deployment appointment (even though they initially agreed at the time of recruitment). Twenty percent of interested households could not be reached, and 46% of the interested households were not attempted.

This final group was not attempted because of the time and equipment constraints associated with the GPS effort: the deployment team had a set number of units to provide to households for a given travel day. They randomly contacted the interested households, but stopped once they reached sufficient deployments to cover a given travel day. A total of 41 GeoLoggers were provided at the start of the in-vehicle GPS study to support the goal of 12 households deployed per week for a one-day deployment period. A new deployment person was added in mid March and another 6 GeoLoggers were provided for this person. Once the study switched to a seven day study in May, an additional 9 loggers were supplied to the team, increasing the final number of in-vehicle GeoLoggers provided for the study to 56 to be rotated among the participating households.

For households that agreed to accept the in-vehicle GPS units, they had the option of deployment team members installing the equipment in any or all vehicles present at the time of equipment delivery or self-installation (the priority was to obtain permission for team members to install the units). Installation consisted of inserting the power cord into the power outlet and placing the receiver/antenna on dashboard. Power splitters were provided with each GeoLogger and participants were asked to use these if they needed to power another device (such as a mobile phone or music device) as well as the GeoLogger. Simple instructions were provided with the devices, which also listed the assignment of each logger to each household vehicle based on the logger identification number (to help with data reconciliation after the deployment period). Households were reminded of the importance to also use their travel logs to record their travel for the assigned travel date and were offered travel logs if theirs had not yet arrived in the mail.

GPS Equipment Retrieval

At the time of equipment delivery, the deployment team person scheduled a date and time to pick up the equipment – this was scheduled as soon after the deployment period was complete as possible to free up units for deployment to the next cohort of households. Once the equipment was retrieved, the data were downloaded from each device and transmitted to GeoStats via the password-protected project website, where it was imported into a GPS database.

The following table shows the results of the deployment effort with respect to collecting both CATI and GPS data on the assigned travel date. Complete GPS and CATI data are available for 172 households out of the 300 households deployed in this study. A complete (GPS + CATI) household is defined as one in which CATI data was retrieved and GPS data were either collected from each instrumented vehicle on the assigned travel date or, if not collected from a given vehicle on the assigned travel date, then the CATI data confirmed no travel for that vehicle. However, as indicated in Table 3, GPS data is available for an additional 95 households that can be used in a variety of GPS-based analyses.

TABLE 3: DISPOSITION OF IN-VEHICLE GPS DEPLOYMENT EFFORTS

DEPLOYMENT OUTCOME	FREQUENCY	PERCENT
Complete (GPS + CATI)	172	57%
GPS data and CATI data, date discrepancy	5	2%
Full GPS data but no CATI data	32	11%
Partial GPS data and full CATI data	58	19%
Partial GPS data but no CATI data	0	0%
No GPS data but full CATI data	32	11%
No GPS data and no CATI data	1	0%
Total	300	100%

In Stage 3 of the GPS effort (changed from a 1-day to a 7-day deployment period), tracking efforts entailed an additional dimension – that of data collection across the entire week deployed. The following table shows the number of trips made by deployment day for all vehicles instrumented during the study (this includes both complete and partial GPS households).

TABLE 4: TOTAL IN-VEHICLE GPS TRIPS CAPTURED BY DEPLOYMENT DAY

Deployment Duration	Number of GPS Trips Captured						
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	333	--	--	--	--	--	--
7	1607	1449	1327	1370	1301	1296	1258

Table 5 shows the breakdown of GPS households based on the Stage of the study, along with participation rates by deployment duration.

TABLE 5: SUMMARY OF IN-VEHICLE GPS PARTICIPATION BY STAGE

STAGE	TRAVEL DATES	DEPLOYMENT DURATION	# GPS INTERESTED	# GPS DEPLOYMENTS	# GPS/ CATI COMPLETES	# WITH GPS DATA DAYS 2 - 7
1 and 2	3/4/07 – 5/12/07	1 day	70	44	28	NA
3	5/13/07 – 10/31/07	7 days	1327	256	144	212
Total			1397	300	172	212

GPS Data Processing

Each GeoLogger was programmed to store date, time, position, and speed information for each second that the vehicle was in motion. As noted above in Table 3, some households had partial or no GPS data recorded. This resulted when they neglected to plug the power cord in (for self-installation) or because they were unaware that the vehicle's cigarette lighter was non-functioning. However, it was also possible that the vehicle was not used on the travel day, and thus the lack of GPS data was a correct reflection of the vehicle's lack of movement on the travel day (in those cases, the GPS data was considered "complete").

As the GPS data were received, automated processes converted the second-by-second GPS data streams into a GIS-compatible format. Next, each file was processed using an in-house developed software system (TIAS) to identify potential trip ends based on time intervals between consecutively logged points. (For this study, all initial dwell times of 120 seconds or more were flagged as potential trip stops.) The GPS trip data were then visually reviewed by analysts to screen out traffic delays and other falsely identified stops with dwell times of 120 seconds or more, as well as to add stops that had dwell times of less than 120 seconds but had clear stop characteristics. Once this step was completed, the updated GPS-based trip file for a given household vehicle was ready to be compared with the CATI data for that same vehicle.

On a weekly basis, NuStats transmitted to GeoStats a file containing the travel data reported by the GPS households during the CATI retrieval interview. GeoStats analysts used software to translate each file into a vehicle-based file (changing the focus from each place visited by each household member to each stop made by each household vehicle). The final GPS data set contains data for the 302 vehicles instrumented in the 172 GPS/CATI complete households as well as all GPS trips captured in the 58 partial GPS households.

The demographic characteristics of the GPS households compared to all households participating in the study are shown in Table 6. As shown in that table, the GPS households were smaller than the general survey population households, owned more vehicles (by definition since 0-vehicle households were excluded), had higher incomes, and were not likely to be of minority descent, on average.[1]

TABLE 6: CHARACTERISTICS OF IN-VEHICLE GPS HOUSEHOLDS

	All 24-hour Recruits	GPS Interested Recruits	All Completes	In-Vehicle GPS Completes	CMAP Region Census Data
Household Size					
1	28.2%	22.3%	26.3%	30.8%	26.4%
2	34.7%	37.0%	28.7%	36.6%	28.7%
3	14.9%	16.3%	16.0%	11.7%	16.2%
4+	22.2%	24.4%	28.9%	20.9%	28.9%
Household Vehicles					
0	11.1%	0.0%	13.8%	0.0%	14.3%
1	35.7%	35.4%	31.3%	40.7%	36.3%
2	37.7%	45.4%	34.9%	44.8%	36.1%
3+	15.5%	19.2%	20.0%	14.5%	13.3%
Household Income					
< $20k	13.0%	5.1%	17.9%	3.8%	16.9%
$20k - < $35k	11.6%	8.6%	16.6%	8.8%	15.7%
$35k- < $50k	14.2%	13.8%	15.9%	13.8%	15.3%
$50k - < $75k	19.0%	20.3%	20.4%	21.4%	20.9%
$75k - < $100K	16.0%	17.8%	10.0%	22.0%	12.9%
$100k +	26.2%	34.4%	19.1%	30.2%	18.3%
Income refusals	12.1%	6.5%	6.8%	7.6%	--
Residence Type					
Single family	60.3%	66.2%	49.6%	73.3%	55.6%
All other types	39.7%	33.8%	50.4%	26.7%	44.4%
Ethnicity					
White	75.0%	77.1%	66.6%	89.5%	65.5%
Black/African American	11.5%	10.0%	19.3%	7.0%	18.9%
Other	13.5%	12.9%	14.1%	3.5%	15.6%
Hispanic					
Yes	8.9%	8.8%	17.7%	4.7%	17.2%
No	91.1%	91.2%	82.3%	95.3%	82.8%
Respondent Age					
<20	24.1%	24.3%	39.6%	24.5%	29.5%
20 - 24	4.4%	5.0%	5.0%	2.8%	6.7%
25 - 54	40.2%	42.8%	41.4%	40.3%	45.1%
55 - 64	14.2%	14.5%	5.6%	16.1%	8.0%
65+	17.1%	13.4%	8.4%	16.3%	10.7%
Age refusals	2.9%	2.2%	2.0%	1.0%	--

[1] For more information regarding non-response and technology biases in GPS data sets, see http://www.isctsc.let.fr/2008Conf/workshops.html Workshop A2 Resource paper

Source: CHRTI 24-hour Recruitment Data, unweighted, CHRTI 24-hour retrieval data, weighted, 2000 Census.

As indicated in Table 6, the GPS households differ from the general inventory members in that they reported smaller household sizes, higher incomes, are more likely to live in a single-family dwelling, and are not as likely to be of minority descent. These differences between the GPS and non-GPS households is common in US travel studies, and result both from a technology bias as well as general participation issues for travel studies. Research is now underway to design GPS studies that mitigate both types of biases.

The demographic differences noted are all associated with higher trip rates, particularly the differences in income. As was noted earlier in this report, the in-vehicle study over-sampled heavy travelers in the region, thus the demographic differences are also a by-product of the in-vehicle GPS study design. As shown in Table 7, the GPS households indeed reported higher trip rates as compared to non-GPS households, except for 2-person households, where the trip rates were not statistically different.

TABLE 7: HOUSEHOLD TRIP RATE COMPARISON (IN-VEHICLE EFFORT)

Household Size	In-Vehicle GPS Households	Non-GPS Households	All Households
1	5.79 +/- 0.54	4.00 +/- 0.04	4.03 +/-0.04
2	8.28 +/- 0.49	8.31 +/- 0.08	8.30 +/- 0.07
3	10.41 +/- 0.81	9.34 +/- 0.11	9.35 +/- 0.11
4+	16.88 +/- 1.16	15.32 +/- 0.13	15.33 +/- 0.13
Total	9.27 +/- 0.44	9.34 +/- 0.06	9.34 +/- 0.06

ON-PERSON GPS EFFORT

In Stage 4 of the GPS effort, an on-person GPS component of the CHRTI was introduced. The focus of this effort was to equip members of 160 households with wearable GPS devices for 7-day deployment periods. The goal was to capture non-motorized travel (transit, walk, and bike). Eligible households were those who answered affirmatively to the screening questions of whether anyone in the household on a regular basis used transit or walked/biked to work/school.

Unlike the in-vehicle GPS effort, which utilized in-person deployment, the wearables component used the US Postal Service to deliver the GPS units to the household. This mail-out/mail-back approach was administered from within the Chicago region by a GPS deployment team member (see below for more details on the deployment effort).

As with the in-vehicle GPS effort, the on-person GPS effort centered around five main activities: (1) identification of interested households, (2) identification of households eligible for the wearable portion of the study (3) recruitment, (4) deployment of equipment, (5) retrieval of equipment, and (6) data processing. The final tasks included a comparison of CATI-reported vs. GPS-captured trips and conducting the prompted recall survey, as well as the creation of the final data files. This section of the report provides details about each of these stages.

Identification of Interested Households

As with the in-vehicle GPS effort, as households agreed to participate in the 24-hour component of the Travel Tracker Survey, the CATI program was structured to flag households that met eligibility requirements for inclusion in the on-person GPS effort. The criteria for inclusion in this effort was that the household responded affirmatively to one of two screening questions, indicating that someone in the household on a regular basis used transit or walked/biked to work/school. As eligible households were identified, the CATI prompted the interviewer to read a prepared script to gauge interest in participating. Note that if a household was eligible for both the in-vehicle and on-person GPS efforts, participation in the on-person effort was offered to the household.

FIGURE 5: INTEREST IN ON-PERSON GPS STUDY PARTICIPATION

In addition to asking everyone to record their travel information in the travel log, we're selecting a handful of households to help test the use of Global Positioning System, or GPS, technology, in conducting travel surveys. If selected, we would contact you and mail GPS devices to you for each person in your household of age 16 and older. All you would need to do have each person carry or wear their GPS device for one week and to charge each device every night during this week. The process is very simple and the results of this test can lead to improved travel studies in the future. If selected, will you help us with the GPS test?

Of the 10,121 households recruited for the 24-hour portion of the Travel Tracker Survey, 2,741 (27%) were eligible for inclusion in the on-person GPS effort. Of the 2,741 households eligible for inclusion, 1,217 indicated they were interested in participating in this GPS effort. Table 8 shows the characteristics of the 1,217 interested households as compared to all households recruited into the 24-hour Travel Tracker Survey. As indicated therein, households interested in on-person GPS were larger, owned fewer vehicles, were likely to be at the lower or upper ends of the income ranges (thus without vehicles by necessity or choice). This sample had a good distribution of households by race.

TABLE 8: CHARACTERISTICS OF HOUSEHOLDS INTERESTED IN ON-PERSON GPS

	All 24-hour Recruits	On-Person GPS Interested Recruits	CMAP Region Census Data
Household Size			
1	28.2%	20.2%	26.4%
2	34.7%	28.2%	28.7%
3	14.9%	19.4%	16.2%
4+	22.2%	32.2%	28.9%
Household Vehicles			
0	11.1%	22.5%	14.3%
1	35.7%	34.0%	36.3%
2	37.7%	30.5%	36.1%
3+	15.5%	13.0%	13.3%
Household Income			
< $20k	13.0%	20.7%	16.9%
$20k - < $35k	11.6%	11.6%	15.7%
$35k- < $50k	14.2%	13.7%	15.3%
$50k - < $75k	19.0%	16.9%	20.9%
$75k - < $100K	16.0%	13.3%	12.9%
$100k +	26.2%	23.7%	18.3%
Income refusals	12.1%	6.7%	--
Residence Type			
Single family	60.3%	51.5%	55.6%
All other types	39.7%	48.5%	44.4%
Ethnicity			
White	75.0%	70.9%	65.5%
Black/African American	11.5%	17.4%	18.9%
Other	13.5%	11.7%	15.6%
Hispanic			
Yes	8.9%	8.0%	17.2%
No	91.1%	92.0%	82.8%
Respondent Age			
<20	24.1%	31.9%	29.5%
20 - 24	4.4%	5.4%	6.7%
25 - 54	40.2%	42.6%	45.1%
55 - 64	14.2%	11.7%	8.0%
65+	17.1%	8.4%	10.7%
Age refusals	2.9%	84%	--

Source: CHRTI 24-hour Recruitment Data, unweighted.

GPS Study Recruitment

Unlike the in-vehicle GPS effort, which utilized in-person deployment teams, the on-person GPS effort was designed for a mail-out/mail back deployment approach. This was handled by a deployment team member located in the Chicago region.

As with the in-vehicle GPS effort, on-person GPS interested households were flagged during the daily processing and files transmitted to GeoStats three times a week via a secure file transfer site. Upon receipt, GeoStats imported the file into a wearable GPS household database where the details regarding the interested households appeared on a secure website for the deployment team to initiate the scheduling of deployments.

Equipment Deployment

Equipment deployment for the on-person GPS effort was handled by one deployment team member (who also deployed in-vehicle units). This team member signed onto the password-protected website daily to review the upcoming deployment possibilities. The lead time between the posting of recruited households to the website and the assigned travel date was at least seven days, allowing sufficient time to reach the households and to mail the GPS equipment prior to the assigned travel date.

The deployment person phoned each household and implicitly confirmed their willingness to participate in the wearable GPS portion of the study by confirming their mailing address. If they confirmed this address, then the equipment was configured and mailed via the US Postal Service to the household. Detailed instructions pertaining to equipment use and start date were included in the box, along with a return FedEx envelope, allowing the household to return the equipment in the same packaging in which it was received. This method of mail out / ship back provided for an efficient and economical approach to deployment while supporting a quick turnaround of equipment and tracking capabilities for lost or delayed packages.

Easy-to-follow instructions were included in the package mailed to each household; these instructions included details about the GPS equipment, how and when it should be worn/carried/charged, as well as shipping procedures for equipment return. Each household received a GlobalSat GPS device for up to five household members age 16 and older and were asked to have all household members record their trips in their travel logs for the first travel day of the 7-day GPS deployment period.

The deployment effort results are shown in Table 9, by geographic strata. Of the 1,217 interested households, 1025 were eligible for deployment (the remaining 192 cases did not have a home address geocoded at the time of recruitment). Deployment was attempted for 160 households – 147 successfully deployed, 6 refused on delivery, and 13 to whom equipment was sent but never received back.

TABLE 9: ON-PERSON GPS DEPLOYMENT OUTCOMES

Strata	Total Recruited	Deployed	Refused on delivery	Equipment Not Returned	Refused when called	Could never reach	Not Attempted
1	82	15	1	3	14	29	20
2	174	26	1	1	28	40	78
3	491	62	3	7	55	88	276
4	223	30	1	2	23	49	118
5	55	14	0	0	6	17	18
TOTAL	1025	147	6	13	126	223	510
%	100%	14.3%	0.6%	1.3%	12.3%	21.7%	49.8%

Of the households not deployed to, 12% refused to participate when contacted regarding deployment, contact could not be reached with 22% of them, and 50% were not attempted. As with the in-vehicle GPS effort, this final group was not attempted because of the time and equipment constraints of the study. A total of 70 GlobalSat GPS devices with power chargers and USB extension cables were provided at the start of the wearable GPS study to support the goal of 10-12 households deployed per week for a seven-day deployment period. However, another 27 loggers were supplied in November when it was discovered that the delay in households returning equipment was substantially longer than initially estimated, increasing the final number of GlobalSat GPS devices provided for the study to 97.

Since the units were deployed by mail, the deployment team member handling the on-person GPS effort offered to answer any question about the equipment once it was received. Each household member of age 16 and older was asked to wear the GPS device each time they went outdoors or traveled away from home during the weeklong deployment period. They were also asked to charge the GPS device each evening and ensure that it was powered on before leaving the home the next day. Simple instructions were provided with the devices, which also listed the assignment of each logger to each household member based on the logger identification number and color code. A colored sticker was placed on each device to help family members differentiate between GPS devices. Households were reminded of the importance to also use their travel logs to record their travel for the assigned travel date and were asked to notify the project team if theirs had not yet arrived in the mail by the time the equipment arrived.

GPS Equipment Retrieval

On the last day of the deployment period (Day 7), the deployment team person phoned the household and requested that the equipment be mailed back the following day. Once the equipment was retrieved, the data were downloaded from each device and transmitted to GeoStats via the secure project website, where it was imported into a database.

The following table shows the results of the deployment effort with respect to collecting both CATI and GPS data on the assigned travel date (Day 1 of the 7-day deployment period). Complete GPS and CATI data are available for 77 households out of the 160 households deployed in this study. A complete (GPS + CATI) household is defined as one in which CATI data was retrieved and GPS data were either collected from each instrumented person on the assigned travel date or, if not collected from a given person on the assigned travel date, then the CATI data confirmed no travel for that person. In addition to these GPS/CATI "completes", GPS data is available for an additional 47 households for use in a variety of analyses.

TABLE 10: DISPOSITION OF ON-PERSON GPS DEPLOYMENT EFFORTS

DEPLOYMENT OUTCOME	FREQUENCY	PERCENT
Complete (GPS + CATI)	77	48%
GPS data and CATI data, date discrepancy	3	2%
Full GPS data but no CATI data	31	19%
Partial GPS data and full CATI data	13	8%
Partial GPS data but no CATI data	0	0%
No GPS data but full CATI data	24	15%
No GPS data and no CATI data	0	0%
Equipment Not Yet Returned	12	8%
Total	160	100%

In moving from an in-vehicle to an on-person study, the trip focus expands from vehicle-based trips to all trips (since the on-person units detect trips regardless of mode used). At the same time, the respondent burden increases significantly as well, from simply remembering to keep the in-vehicle unit plugged into a vehicle's power outlet to nightly charging and remembering to carry the on-person unit for all trips. The increased burden is reflected in Table 11, where the number of trips declines as a result of a decrease in the number of household members carrying their units. This table shows reasonable compliance for collecting GPS data for the first four days, with a significant drop-off experienced on day five.

TABLE 11: TOTAL ON-PERSON GPS TRIPS CAPTURED BY DEPLOYMENT DAY

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
#trips	936	929	954	862	745	674	645
#persons	160	169	165	163	139	129	115

Table 12 shows the deployment statistics for the on-person GPS effort.

TABLE 12: TOTAL ON-PERSON GPS TRIPS CAPTURED BY DEPLOYMENT DAY

DEPLOYMENT DURATION	DATE RANGE	# GPS RECRUITS	# GPS DEPLOYMENTS	# GPS/ CATI COMPLETES	# WITH GPS DATA DAYS 2 - 7
7 days	9/3/07 – 12/29/07	1025	160	77	110

GPS Data Processing

Each GlobalSat Data Logger was programmed to store date, time, position, and speed information every five seconds that the household member was in motion. As noted above in Table 10, some households had partial or no GPS data recorded. This resulted when they neglected to take the GPS with them while outdoors, properly charge the GPS device or when they did not turn the GPS on before leaving the house. However, it was also possible that the person did not travel outside the home on the travel day, and thus the lack of GPS data was a correct reflection of the person's lack of travel on the travel day.

As the on-person GPS data were received, automated processes converted the GPS data streams into a GIS-compatible format. Next, each file was processed using an in-house developed software system (TIAS) to identify potential trip ends based on time intervals between consecutively logged points. (For this study, all initial dwell times of 120 seconds or more were flagged as potential trip stops.) The GPS trip data were then visually reviewed by analysts to screen out traffic delays and other falsely identified stops with dwell times of 120 seconds or more, as well as to add stops that had dwell times of less than 120 seconds but had clear stop characteristics. A speed chart was also displayed along with the transit system network so that analysts could easily identify trips and trip segments made in non-auto travel modes or multiple travel modes (more on this in following section on unique challenges in wearable study).

The demographic characteristics of the on-person GPS households are compared to all CHRTI households is shown in Table 13. As indicated therein, on-person GPS households are larger, tended to be higher income, and own their own home. In addition, they tended to non-minority status. Although the sample of interested households had more diversity, the final on-person data set tends to reflect the same biases noted the in-vehicle effort.

TABLE 13: CHARACTERISTICS OF ON-PERSON GPS HOUSEHOLDS

	All 24-hour Recruits	On-Person GPS Interested Recruits	All Completes	On-Person GPS Completes	CMAP Region Census Data
Household Size					
1	28.2%	20.2%	26.3%	16.9%	26.4%
2	34.7%	28.2%	28.7%	24.7%	28.7%
3	14.9%	19.4%	16.0%	20.8%	16.2%
4+	22.2%	32.2%	28.9%	37.6%	28.9%
Household Vehicles					
0	11.1%	22.5%	13.8%	10.4%	14.3%
1	35.7%	34.0%	31.3%	31.2%	36.3%
2	37.7%	30.5%	34.9%	44.2%	36.1%
3+	15.5%	13.0%	20.0%	14.2%	13.3%
Household Income					
< $20k	13.0%	20.7%	17.9%	9.5%	16.9%
$20k - < $35k	11.6%	11.6%	16.6%	5.4%	15.7%
$35k- < $50k	14.2%	13.7%	15.9%	2.7%	15.3%
$50k - < $75k	19.0%	16.9%	20.4%	21.6%	20.9%
$75k - < $100K	16.0%	13.3%	10.0%	24.3%	12.9%
$100k +	26.2%	23.7%	19.1%	36.5%	18.3%
Income refusals	12.1%	6.7%	6.8%	3.9%	--
Residence Type					
Single family	60.3%	51.5%	49.6%	70.1%	55.6%
All other types	39.7%	48.5%	50.4%	29.9%	44.4%
Ethnicity					
White	75.0%	70.9%	66.6%	81.8%	65.5%
Black/African American	11.5%	17.4%	19.3%	11.7%	18.9%
Other	13.5%	11.7%	14.1%	6.5%	15.6%
Hispanic					
Yes	8.9%	8.0%	17.7%	3.9%	17.2%
No	91.1%	92.0%	82.3%	96.1%	82.8%
Respondent Age					
<20	24.1%	31.9%	39.6%	39.5%	29.5%
20 - 24	4.4%	5.4%	5.0%	0.9%	6.7%
25 - 54	40.2%	42.6%	41.4%	50.0%	45.1%
55 - 64	14.2%	11.7%	5.6%	8.7%	8.0%
65+	17.1%	8.4%	8.4%	0.9%	10.7%
Age refusals	2.9%	84%	2.0%	3.1%	--

Source: CHRTI 24-hour Recruitment Data, unweighted.

The demographic differences noted are all associated with higher trip rates, particularly the differences in income. As shown in Table 14, the on-person GPS households indeed reported higher trip rates as compared to non-GPS households, except for 1- and 2-person households, where the trip rates were not statistically different.

TABLE 14: HOUSEHOLD TRIP RATE COMPARISON (ON-PERSON EFFORT)

Household Size	On-Person GPS Households	Non-GPS Households	All Households
1	3.92 +/- 1.11	4.03 +/- 0.04	4.03 +/-0.04
2	10.67 +/- 3.34	8.30 +/- 0.07	8.30 +/- 0.07
3	13.21 +/- 2.06	9.34 +/- 0.11	9.35 +/- 0.11
4+	25.66 +/- 2.43	15.28 +/- 0.13	15.33 +/- 0.13
Total	16.85 +/- 1.84	9.31 +/- 0.06	9.34 +/- 0.06

On-Person GPS Study – Unique Challenges

As noted earlier, this on-person GPS effort is the first time that on-person units have been deployed as part of a full-scale regional study. As such, it posed some unique challenges to the project team, as noted below.

Equipment Retrieval

This effort used a mail-out/mail-back deployment approach. While the outbound placement of units was efficient and placed the units within the households prior to the assigned travel day, the return of units did not happen as efficiently or timely as was hoped. This required GeoStats to provide 39% more on-person GPS units than originally projected as needed to meet the goals of 160 deployments over 16 weeks.

In addition, an equipment retrieval escalation process was implemented in October to retrieve equipment that had not been returned in a timely manner. Specifically, on the 21st day after the end of the original deployment period, a reminder letter was mailed to the household thanking them for their participation in the study and requesting that they return the equipment immediately. A phone number was provided if they had any questions or issues regarding equipment return. If a household had not responded after an additional two weeks, a visit to the household was attempted by one of the in-vehicle deployment staff (retired police officers). If there was a household member present at the time of the visit, the deployment person requested the equipment. If nobody answered at the home, a letter was left for the household requesting them to call to schedule a time for the equipment to be retrieved.

After the study was complete and all attempts at equipment retrieval were exhausted, there were a total of 13 households with 24 devices that were not returned. This is approximately a 25% loss in equipment. While some equipment loss was expected due to the mail-out/ship-back method, the 25% loss was more than expected given that repeated attempts (phone, letters, in person) were made to secure the equipment. It was expected that the majority of equipment loss would be attributable to the shipping method. That expectation was incorrect – the majority of equipment loss was attributed to a household's failure to return equipment and the inability of the deployment person to contact the household successfully for equipment retrieval.

Future studies should consider carefully the costs of in-person deployment (as used for the in-vehicle effort) vs. the costs of lost equipment with the mail-out/mail-back approach.

GPS Data Processing

Processing wearable GPS data also presented some unique challenges mainly due to the fact that the devices, when used as instructed, were continuously powered on and worn by a person. As a result, there were a higher number of GPS points that needed to be translated into trips. During the trip identification process, three issues in particular were noted: identifying phantom trips versus short walk trips, identifying multi-modal trips, and identifying trips ends in urban canyons. These are discussed in more detail below.

1. Phantom Trip Identification / Short Walk Trips

Phantom trips are GPS trips captured when the respondent is wearing the unit inside (the GPS device maintains a weak signal and captures the trips when in motion as when the respondent is outside). When this happens, an artificial speed and distance is derived from the satellites which can produce GPS points that have a similar signature to a walk trip. These 'trips' occur most often near the home or office. During processing, phantom trips were blocked from the trip data deliverable. It is possible that during this cleaning process, short walks near the home (to/from the mailbox) or office (next door for lunch) were blocked and not included in the data delivery. Every attempt has been made to differentiate these true trips from phantom trips. In all, more than 2.2 million points were blocked out of the 3.1 million points collected in the on-person GPS effort –71% of all points captured.

2. Multi-Modal Trips / Train Trips and Transfers

One of the benefits of an on-person GPS effort is the ability to capture all trips, including non-motorized and transit trips in addition to the traditional vehicle trips. In processing the data, a combination of two or more of these modes was considered a multi-modal trip. In the metropolitan Chicago area, many train lines run along non-limited access highways, resulting in a challenge in the identification of train versus vehicle trips. GeoStats relied on the GIS data layers for train stops and tracks, aerial photo interpretation and speed graphs to infer train versus vehicle trips. Most train trips were multi-modal and involved transportation to the train station (often vehicle to a parking lot), the train ride and a walk to the destination. There were gaps in the GPS trace when the signal was lost because the train went underground, was in an area with many tall buildings or the GPS was blocked by other travelers on the train. In most cases, the trace resumed once the obstruction was gone so the origin and destination of the trip was captured. There were cases where the participant changed trains in downtown Chicago. In some of these cases a few GPS points were captured at the transfer location, in other cases no points were captured at the point of transfer. When captured, those points were included as part of the multi-modal trip.

3. Urban Canyon Issue

As anticipated, the density of tall buildings in some areas of downtown Chicago reduced the availability the GPS signals and, in some cases, caused them to be non-existent. Urban canyon impacts on GPS data can cause bad position calculations or the total absence of GPS points. Every attempt was made to differentiate between valid GPS trip ends and those places where the signal was lost due signal blockage. The presence of geocoded habitual locations and previous participant travel patterns were used to determine the correct trip origins and destinations in these cases.

TRIP UNDER-REPORTING

In addition to capturing travel patterns for analysis regarding mode and route choice, the GPS detected trip data was compared to the CATI-reported data to determine the level of completeness of the CATI-reported data. That process is documented here, for both the in-vehicle and on-person GPS efforts.

IN-VEHICLE GPS EFFORT

The purpose of this section is to summarize the process used to compare data from the two data sources (in-vehicle GPS and respondent-reported CATI) and to provide preliminary findings regarding the completeness of the CATI data. The results suggest a very low rate of vehicle driver trip under-reporting in the data file, suggesting very accurate CATI reported data. This section presents the trip comparison process and identifies the level of trip-underreporting documented among participating households. All discussions about trip-making in this section focus specifically on vehicle-driver trips from the 172 households for whom both GPS and CATI data are available.

During the GPS trip processing and CATI trip comparison process, GeoStats analysts identified a total of 1,398 vehicle driver trips in the GPS data stream for these 172 households. This represented vehicular travel across 302 household vehicles. The corresponding CATI data indicated that members of the participating households reported 1,341 vehicle-driver trips using those same 302 vehicles.

The trip comparison process was done with customized software developed by GeoStats (the Trip Identification and Analysis System or TIAS). This program was designed to compare individual vehicle driver trip records in each vehicle file using location and time as the significant variables for matching. The location and times in the GPS data represented where the vehicle stopped or was parked and were logged automatically by the unit. Respondents reported a location and time during the retrieval interview. It should be noted that the time reporting has inherent inaccuracies, resulting from respondents who park at their location. In this case, the GPS Unit records arrival time as the time the vehicle is turned off, while the person typically reports the time they arrived inside their destination (after a short walk from a parking lot). In recognition of this, analysts reviewed the times and locations to confirm accurate matches using time and distance thresholds as guidelines to reflect the imperfect reporting mechanisms. Matched results and discrepancies fell into the following categories:

Matched Trips. GPS and CATI trips that matched according to location and time comprise the first category. To account for measurement differences (i.e., where vehicle was parked vs. where the respondent went), time thresholds of 12.5 minutes and distance thresholds of 100 meters were used. This means that times were considered a match if within 12.5 minutes of each other and/or locations were considered a match if found to be within 100 meters of each other.

Of all trips made by the 302 vehicles, 127 vehicles had perfect matches between the CATI and GPS trip data. To this number were added the 55 vehicles that had no GPS data for the travel day and were reported as not used on the travel day in the CATI data, which is also a "match." Thus, the total number of vehicles with fully matched trips was 182 or 60% of all instrumented vehicles. This represents 694 of the 1341 CATI-reported vehicle driver trips (52%).

GPS Trip Detected but No CATI Trip Reported. The second category in the matching process contains those cases where trips were identified within the GPS data stream but not within the CATI data. These "missed" CATI trips were tagged as single links within a trip chain, multiple links within a trip chain, or as complete round-trips missing all links in a tour based on where the missed trip fell within the vehicle's travel for the 24-hour period. As reported above, the CATI data showed 1,341 vehicle driver trips while the GPS equipment captured 1,398 trips, for a net difference across the entire study of 57 vehicle driver trips (4.3% missed trips).

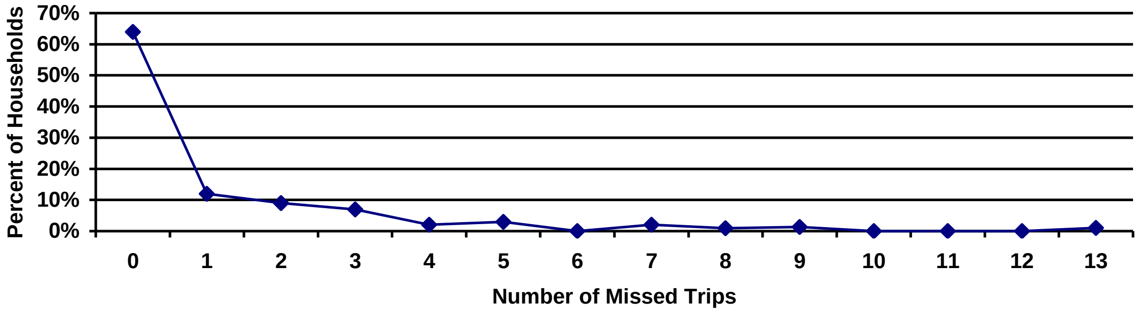
To summarize the findings of the trip comparison task, the results are shown in Table 15. This shows the number of GPS households by stratum, the number of vehicles instrumented in these households, the total number of GPS-identified trips after the review process for all instrumented vehicles (GPS trips), the total number of CATI-reported trips associated with the same household vehicles (CATI trips), the number of missed CATI trips identified (Missed trips), and the proportion of missing trips by stratum (% missed). The missed trips total reflects all trips detected in the GPS data that were not reported. These numbers have already been adjusted for the three out of region trips found as well as the seven trips reported to be 'not a stop' in the prompted recall survey (discussed in the next section).

TABLE 15: IN-VEHICLE TRIP REPORTING COMPARISONS

Stratum	Households	Vehicles	GPS Trips	CATI Trips	Missed Trips	% Missed Trips
1	55	105	581	569	12	2.1%
2	65	116	475	442	33	7.5%
3	37	62	274	262	12	4.6%
4	10	13	59	58	1	1.7%
5	5	6	9	10	0	0.0%
TOTAL	172	302	1398	1341	57	4.3%

Figure 6 summarizes the incidence of missed trips across the 172 households. As shown in that figure, two-thirds of the households (110 or 64%) had no missed trips (the CATI and GPS data matched exactly). Of the remaining 62 households, 12% had only 1 missed trip, 9% had 2 missed trips and 7% had 3 missed trips. The highest number of missed trips was 13 for any given household, although the average was 1.4 missed trips per household. These data suggest that most households are fairly accurate reporters of their travel, with the majority of missed trips coming from a very low number of households. This is a marked improvement from early GPS studies, reporting missed trip rates of nearly 30%, and reflective of the research into the missed trip phenomenon and resulting design improvements that NuStats has put in place to mitigate trip under-reporting.

FIGURE 6: INCIDENCE OF MISSED VEHICLE DRIVER TRIPS IN CATI DATA



ON-PERSON GPS EFFORT

The trip comparison process for the on-person GPS effort paralleled that used for the in-vehicle GPS effort. As a result of the GPS trip processing and CATI trip comparison process, GeoStats analysts identified a total of 769 person trips in the GPS data stream for the77 households where complete GPS and CATI data were available. This represented personal travel from 146 instrumented persons. The corresponding CATI data indicated the same persons from the participating households reported 796 trips, reflecting a raw difference of 27 trips that were in the CATI data and not in the GPS data.

Matched Trips. Of all trips made by the 146 persons, 60 persons had perfect matches between the CATI and GPS trip data. To this number are added the 5 persons who collected no GPS data for the travel day and who reported no travel on the travel day in the CATI data, which is also a "match." Thus, the total number of persons with fully matched trips was 65 for 45% of all instrumented persons in the 77 complete households. This represents 349 of the 796 CATI-reported person trips (44%).

GPS Trip Detected but No CATI Trip Reported. The second category in the matching process contains those cases where trips were identified within the GPS data stream but not within the CATI data. These "missed" CATI trips were tagged as single links within a trip chain, multiple links within a trip chain, or as complete round-trips missing all links in a tour based on when the missed trip fell within the vehicle's travel for the 24-hour period. As reported above, the CATI data showed 796 driver trips while the GPS equipment captured 769 trips, for a net difference across the entire study of 27 person trips (or -3.3% of all reported CATI trips).

This is the first GPS study performed by NuStats and GeoStats using person-based devices rather than in-vehicle devices – and it is the first time that the raw or gross difference between the GPS trip counts and CATI trip counts was negative. It is very likely that the negative direction of this difference is attributable to the fact that study participants did not always take the device with them on all trips, whereas in the vehicle-based studies, once the equipment was installed, it was not 'forgotten' on a given trip. The primary reason for missing vehicle-based GPS trips has been thought to be a result of power removal – which evidently occurs much less than forgetting to carry a wearable GPS device on the assigned travel date.

To summarize the findings of the trip comparison task, the results are shown in Table 16. This shows the number of GPS households by stratum, the number of persons instrumented in these households, the total number of GPS-identified trips after the review process for all instrumented persons (GPS trips), the total number of CATI-reported trips associated with the same persons (CATI trips), the number of missed CATI trips identified (Missed CATI trips), and the proportion of missing CATI trips by stratum (% missed). These numbers were adjusted for the two out of region trips found as well as the three trips reported to be 'not a stop – work related' during the prompted recall survey.

TABLE 16: ON-PERSON TRIP REPORTING COMPARISONS

Stratum	Households	Persons	GPS Trips	CATI Trips	Missed CATI Trips	% Missed Trips
1	10	23	107	114	-7	-6.1%
2	18	34	194	190	4	2.1%
3	27	50	277	275	2	0.7%
4	14	25	133	154	-21	-13.6%
5	8	14	58	63	-5	-7.9%
TOTAL	77	146	769	796	-27	-3.3%

PROMPTED RECALL SURVEY

For both the in-vehicle and on-person effort, a post-processing prompted recall survey was administered to households when missed trips were detected in the CATI data. The purpose of the survey was to obtain details regarding the unreported trip, assuming that the trip was correctly detected by the GPS trip-detection algorithm.

IN-VEHICLE GPS EFFORT

Once the GPS-measured trips were matched with CATI-reported trips for the assigned travel date, a follow-up survey was conducted with a small sample of GPS households for whom there existed GPS-detected trips without corresponding matches in the CATI data. The survey listed the reported travel for that particular household vehicle, along with a list and map of the GPS-detected trips for which there was no CATI data. The participants were then asked to identify the unreported stops, the vehicle driver, how many household members were with them at the time, the trip purpose, and the reason for not reporting the missing stops/trips in the travel log.

Households selected for inclusion in the prompted recall survey were those whose data showed a "missed trip" and whose CATI data had completed the quality control and geocoding stages. It should be noted that if a household showed a significant number of missing CATI trips, they were excluded from the survey effort as the presentation of the missed trips was deemed to be confusing to the respondent.

The result of this process was the identification of 47 households out of 172 households for whom both CATI and GPS data were available. As shown in Table 17, surveys were mailed to 47 households, with 33 ultimately completing the survey.

TABLE 17: PROMPTED RECALL ADMINISTRATION DETAILS

Travel Dates	# HH Survey Mailed	# HH Returned Survey	# HH Vehicles Mailed	# HH Vehicles Returned
April 2007	5	3	5	3
May 2007	4	4	4	4
June 2007	13	8	13	8
July 2007	6	4	7	5
August 2007	10	7	13	7
September 2007	2	2	2	2
October 2007	7	5	9	6
Totals	**47**	**33**	**53**	**35**

Participants were provided two choices for returning information about their missed trips: by conventional mail or by telephone. Most participants sent their responses back using conventional mail, using the self-addressed stamped envelope provided by GeoStats. A few provided the missing information over the telephone – however, these calls were initiated by GeoStats as follow ups for households that had not returned their materials. Respondents who did not returned the surveys within 14 days received at least one courtesy call, in which the GeoStats representative attempted to complete the survey at that time. A total of 33 households completed the survey, providing details about 55 suspected "missed trips."

For each missed trip, the respondent was asked to indicate why that trip was not reported during the CATI retrieval interview. Of the 55 trips detected in the GPS data but not found in the CATI data, participant-provided data showed that 7 (13%) were not true stops/trips. These were either traffic delays, rerouting due to traffic, or movement of a vehicle at the same location (not recorded in log since there was no change in address). There were also two prompted recall stops (from two separate participants) that were confirmed to be trips to a train station – further inspection of the CATI file revealed that these trips were indeed reported, but were recorded in transit file as access to rail.

For the remaining 46 trips that were true stops and should have been reported, the explanations were mainly that the respondent forgot about the stop. Unreported trip purposes included 2 stops to drop off or pick up someone, 8 stops to "grab some food,", 6 shopping stops, 3 stops to mail a letter, 7 stops for other personal errands, 5 stops for recreation, and 5 stops to visit friends or family. A breakdown in the prompted recall responses appears below. It should be noted that for the seven stops that were reported as Not a Stop, additional GPS processing was done to remove these stops from the dataset. Therefore, these stops are not included in the missed trip analysis performed and have no impact on those results.

TABLE 18: GPS PROMPTED RECALL MISSED TRIP EXPLANATIONS

CATEGORY	REASON FOR NOT REPORTING THE STOP	# STOPS	PERCENTAGE
Forgot	I forgot	30	54.5%
Didn't know	I didn't know about this stop	0	0%
Not important	I didn't think this stop was important	6	10.9%
Other	I ran out of room in the travel log	2	3.6%
Other	I did not receive a travel log for this vehicle	2	3.6%
Other	I thought I reported this trip in the initial phone call	4	7.3%
Other	Trip was reported in the initial log as a different mode	2	3.6%
Other	Used to live here; still think of it as home	1	1.8%
Other	I had to drop off a friend at her car	1	1.8%
Not a stop	This was not a stop - it was a traffic delay, wrong turn, or moving car to another parking space at same location	7	12.7%
	Total	**55**	**100.0%**

ON-PERSON GPS EFFORT

The process to generate a prompted recall survey for the on-person GPS households was the same as for the in-vehicle effort: households with missed trips were identified, a survey focused on identifying the missed trip was generated and mailed to the household, with a follow-up call from GeoStats if not returned within 14 days.

The result of this process was the identification of 26 households out of 77 households providing complete CATI and GPS data. As shown in Table 19, surveys were mailed to 26 households, with 17 ultimately completing the survey.

TABLE 19: PROMPTED RECALL ADMINISTRATION DETAILS

Travel Dates	# HH Mailed	# HH Returned	# Persons Mailed	# Persons Returned
September 2007	8	6	9	7
October 2007	7	5	8	6
November 2007	5	2	5	2
December 2007	6	4	7	4
TOTAL	26	17	29	19

Participants were provided two choices for returning information about their missed trips: conventional mail or by telephone. Most participants sent their responses back using conventional mail, using the self-addressed stamped envelope provided by GeoStats. A few provided the missing information over the telephone – however, these calls were initiated by GeoStats as follow ups for households which had not returned their materials. Respondents who had not returned the surveys within 14 days received at least one courtesy call, in which the GeoStats representative attempted to complete the survey at that time. A total of 17 households completed the survey, providing details about 30 "missed trips."

For each missed stop/trip, the respondent was asked to indicate why that trip was not reported during the CATI retrieval interview. Of the 30 trips identified in the GPS data but not found in the CATI data, participant-provided data showed that 6 (20%) were work-related trips.

For those 24 trips that were true trips that should have been reported, the reason given was that the respondent forgot about the stop. This included 2 stops to drop off or pick up someone, 5 stops to get food from a restaurant, 2 stops for fuel, 6 shopping stops, 2 stops to mail a letter or other personal errands, and 3 stops to visit friends or family.

TABLE 10: GPS PROMPTED RECALL MISSED TRIP EXPLANATIONS

REASON FOR NOT REPORTING THE STOP	# STOPS	PERCENTAGE
I forgot	24	80%
This was a work related trip.	6	20%
Total	30	100.0%